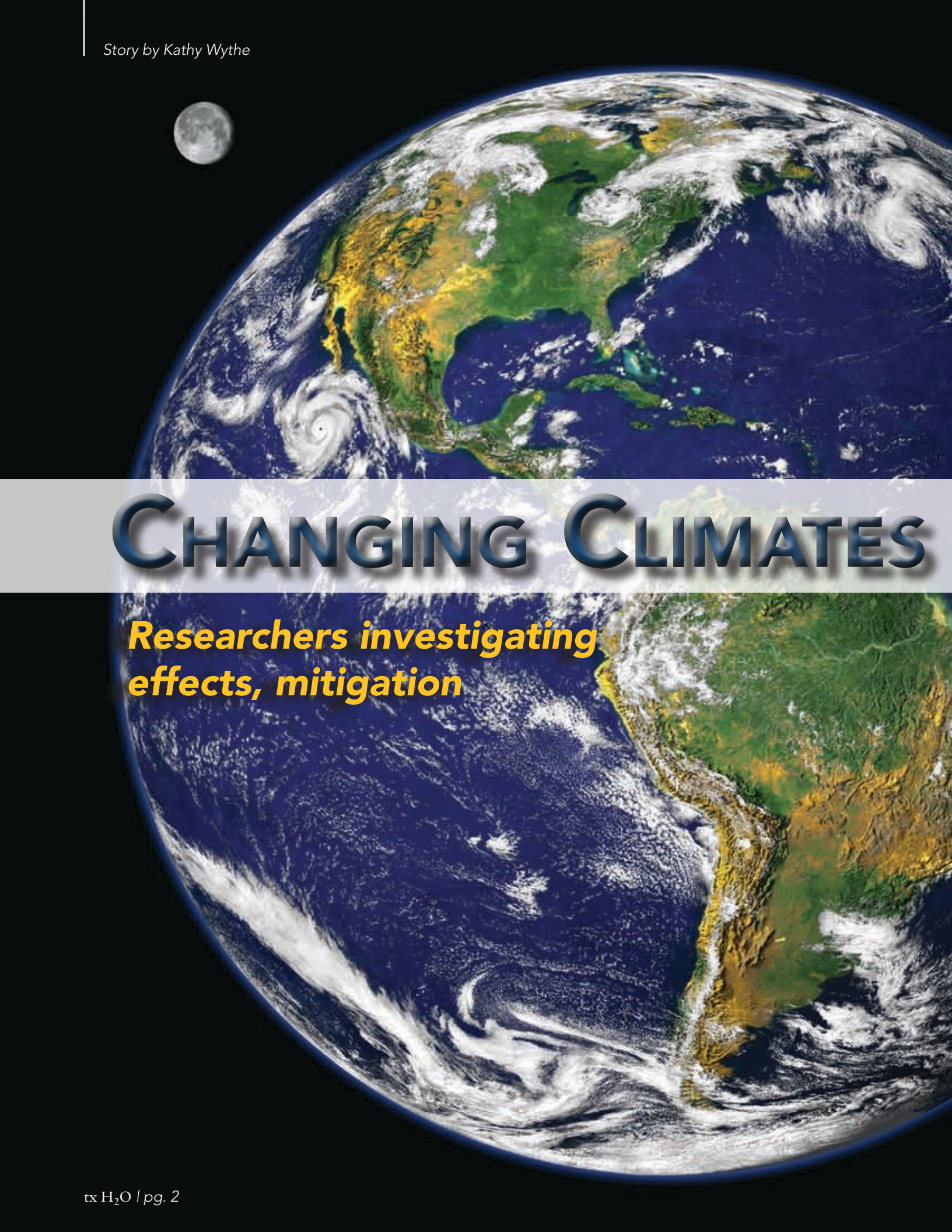
Story by Kathy Wythe



Changing Climates

Researchers investigating effects, mitigation

Editor's note: This story highlights climate change research from only a few scientists in Texas. A more detailed story of their research is available on Texas Water Resources Institute's web site at http://twri.tamu.edu/climatechange. Other researchers are listed at http://twri.tamu.edu/climatechangeresearchers. Additional scientists may be added by clicking on the comment section.

Long before climate change and global warming became such a popular topic, scientists were researching the different aspects of the world's changing climate. In Texas alone, dozens of scientists from different universities and a wide range of academic areas are investigating the different components. More recently, they are taking information gleaned from the global climate models and applying them to research questions pertaining to Texas.

Dr. Bruce McCarl, Regents Professor of agricultural economics at Texas A&M University, has researched the economics of climate change for the last 20 years. McCarl, as a lead

McCarl

author in a 2007 Intergovernmental Panel on Climate Change (IPCC) report, shares in the 2007 Nobel Peace Prize with the other scientists on the panel as well as Al Gore. His research has focused on economic effects of climate change on agriculture and forestry and their possible roles in mitigating climate change.

In his mitigation research, McCarl has proposed that agriculture can help reduce greenhouse gases. The first option, he said, is for agriculture to reduce and control direct emissions by reducing irrigation pumping, which uses energy; reducing fertilizer use, which produces the greenhouse gas, nitrous oxide; and improving manure management of livestock herds. The second way is by modifying agricultural management to enhance the stored carbon, thus increasing carbon sequestration. McCarl said agriculture could also generate products that offset fossil fuel-intensive products.


North

Another Texas A&M researcher, Dr. Gerald North, is an expert on simplified climate models, Earth observing satellites, ancient climates, and the detection and attribution of climate change. The Distinguished Professor of atmospheric sciences recently has been studying climate models to better understand how precipitation, evaporation, and runoff over the Greater Texas region will change over the next century.

North and his colleagues in Texas A&M's Department of Atmospheric Sciences issued a statement supporting the IPCC reports and findings. The statement is available at http://www.met.tamu.edu/climatechange.php.

Katharine Hayhoe, associate professor of geosciences at Texas Tech University, uses global and regional climate model simulations to determine what climate change means to the places where we live. As a current contributor to and expert reviewer of the latest IPCC report, Hayhoe also shared in the Nobel Peace Prize. She is currently collaborating with researchers from the University of Chicago, University of Illinois, and Harvard University on a National Science Foundation grant to develop new statistical methods to relate global climate projections to what will happen at the local scale.


Hayhoe

She said people need specific examples about the effects of climate change, like an increase in the number of days a city might experience over 100 degrees Fahrenheit, or a change in the frequency of drought conditions. "People need this type of information to make decisions," she said, and individual cities need the information to make decisions when planning for the future.

"As individuals, we need to see how climate changes will affect where we live because we are being asked to make lifestyle changes to prevent potentially dangerous impacts of climate changes," she said. "If we don't know what those impacts are likely to be for us personally, it's hard to be motivated to make those changes."


Nielsen-Gammon

Professor of atmospheric sciences at Texas A&M and the state's climatologist, Dr. John Nielsen-Gammon, researches climate variability and change in the past. He has also investigated regional drought causes and mechanisms, including specific meteorological factors that lead to lack of rainfall in the summer, hurricane frequency, and climate data quality.

In one project, he is working with the Institute for Science Technology and Public Policy of The Bush School of Government and Public Service, providing climate data for a project

studying drought and drought variability over the past century in Texas and New Mexico and policy makers' perceptions of drought. His research is specifically "looking at spatial patterns of droughts in the past and frequency and whether precipitation and drought has changed significantly over the past 100 years," he said. He has found that total precipitation has increased in Texas by 10 to 20 percent over the past 100 years.

This project is one of two that are focused on climate change at the Bush School institute, according to Dr. Arnold Vedlitz, director.

Both projects are examining how decision makers and other stakeholders use science information about global climate change in their decision making process. Vedlitz said the researchers have done regional studies on the Gulf Coast, national studies of decision makers, national public opinion polls and interviewed a national sample of climate scientists to determine how different stakeholder groups use climate change information.

The second part of their research is answering the question, "How can we make this information more usable to decision makers?" ⇨

The Texas warming and rainfall manipulation experiment (WARM) is investigating the effects of climate change on oak savanna in Texas. Rainfall exclusion shelters and infrared lamps are used to control rainfall and simulate future climate warming. (Photo courtesy of MG Tjoelker.)

Vedlitz said. The researchers are developing decision tools and models to help decision makers make better use of the information.

Part of the research of Dr. Steven Quiring, Texas A&M assistant professor of geography, is focused on the influence of global climate change on the hydrologic cycle and drought. Using records from the past, Quiring said he can study drought and its natural variability to put it into proper perspective to help detect future changes from climate change.


Quiring

"We need to use the observational record to make sure we understand how the system works," Quiring said. "Once we understand how the system works then that is the jumping off point for climate change."

In research funded by the U.S. Department of Energy through the Southeastern Region of the National Institute for Climatic Change Research, Texas A&M researchers Drs. Mark Tjoelker and David Briske of the Department of Ecosystem Science and Management and Astrid Volder of the Department of Horticultural Science are conducting a large, multi-year experiment near the Texas A&M campus. They are examining the effects of climate warming and drought predicted within the next several decades on the post oak savannas and woodlands of central Texas.

Through three years of controlling the temperature and rainfall to mimic predictions, Tjoelker said their research suggests that juniper will increase in dominance and invasiveness in savanna grasslands with both climate warming and increased summer drought.


Masiello

Dr. Carrie A. Masiello, assistant professor of earth science at Rice University, studies the Earth's carbon cycle on timescales from five to 100,000 years. Her main interests are in fundamental mechanisms of the carbon cycle and how humans are altering these mechanisms through combustion of fossil fuel, land use change, and erosion. Masiello and her group, Rice Isotope Biogeochemistry, are currently studying how changes in climate and land use are controlling river carbon cycling.

At The University of Texas at Austin (UT), researchers at the Environmental Science Institute (ESI)—a multi-disciplinary institute for basic scientific research in environmental studies—are examining different aspects of climate change. Dr. Jay Banner, director, said its work includes climate change history, impacts, remediation and education, climate modeling, records, and abrupt climate change.

Dr. Zong-Liang Yang, associate professor in the Jackson School of Geosciences, and his Land Environmental and Atmospheric Dynamics (LEAD) group are studying the impacts of climate change on a finer scale.


Yang

They are using various computer models to study the interaction of land use and the atmosphere.

For a National Aeronautics and Space Administration grant, Yang, along with other ESI-affiliated researchers, are using a series of nested computer models that integrate climatic, hydrologic, ecological, and atmospheric processes to study how climate change on the global scale will affect people locally. The team is using the computer model to study the Nueces and Guadalupe watersheds.

Other UT researchers involved in the project are Drs. Guo-Yue Niu, Jackson School; David Maidment, Department of Civil, Architectural and Environmental Engineering; James McClelland, Marine Science Institute; and Hongjie Xie, Department of Earth and Environmental Science, University of Texas at San Antonio. Dr. Paul Montagna of the Harte

Research Institute at Texas A&M at Corpus Christi is also a member.

Dr. Charles Jackson, research scientist at the Jackson School's Institute for Geophysics, is an expert in global climate change of the past—particularly episodes of abrupt climate change within the past 100,000 years. Jackson also works on quantifying climate prediction uncertainties in order to understand how records of past change may be used to build confidence in model predictions of the future.

Through a National Science Foundation research grant, Dr. John Holbrook, professor of Earth and environmental sciences at The University of Texas at Arlington, is examining the rates and processes by which the Missouri River changes its pattern and erosion trends due to climate change. Although the area being studied is the Missouri Drainage, he said researchers will gain insight into how the High Plains, including parts of Texas, responded in general to climate change over the past 5,000 years.

Dr. Arne Winguth, assistant professor of earth and environmental sciences at UT at Arlington, has started analyzing recent

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Texas is vulnerable to climate change

Texas is expected to see hotter temperatures, more concentrated rain, higher soil evaporation rates, greater frequency of droughts, higher sea levels with increased hurricane intensities along with lower precipitation and diminished water supplies, according to two Texas A&M University researchers.

"Texas is very vulnerable to climate change," said Dr. Bruce McCarl, Regents Professor in Texas A&M University's Department of Agricultural Economics. "It has a warm, often dry, climate greatly affecting water and energy needs, agricultural and forestry production, pest populations, disease prevalence, and ecological conditions.

"Agricultural production is highly influenced by such conditions and thus is vulnerable to climate change," he said, estimating that Texas will have as much as a 40 percent reduction in acreage in crop production.

Texas is also quite vulnerable if actions are taken to mitigate climate change by reducing greenhouse gas emissions.

"Nationally over 80 percent of the emissions come from petroleum and electricity generation," he said. "Texas emits almost twice the total volume of greenhouse gasses compared with any other U.S. state. This comes from Texas' large petroleum industry and inventory of coal-fired power plants."

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climate records of Texas, particularly the northern part of the state. Winguth plans to process the recent climatic trends in Texas and compare these data with predictions from the IPCC.

Professor of geography at Texas State University, Dr. David Butler, does climate change research mainly in the Rocky Mountains with U.S. Geological Survey funding. He has also done research on how climate change is affecting floods in Central Texas and on the relationships of climate change with range expansions of fire ants and their interaction with native animals.

"Climate change in Central Texas will probably make flood forecasting more unpredictable than ever, as climatic extremes seem to become more common," Butler said.

Dr. Richard Dixon, associate professor of geography at Texas State, researches a vulnerability analysis of tropical systems for Texas coastal counties, the impact of interannual climate variability on temperature and precipitation in Texas, vulnerability of south Texas to tornadoes, and reassessment of storm and flood probabilities for south-central Texas. His doctoral students are investigating regional climate change in the Big Bend National Park area, and spatial and temporal trends in precipitation and evaporation in Texas.

The researchers said that, although Texas scientists are conducting much research, more needs to done, especially at the local level.

"It's been my contention for 20 years that we haven't been doing enough research on this question (climate change) in Texas," said Dr. Gerald North of A&M's atmospheric Sciences department.

To read more about the research or to comment on this story, please visit http://twri.tamu.edu/climatechange. For a list of Texas climate change researchers or to add names, visit http://twri.tamu.edu/climatechangeresearchers.

McCarl stressed that Texas could be "squeezed" economically by attempts to lower emissions, which would increase energy prices and industry costs.

"Furthermore, Texas is expecting a large population growth that will increase its water and energy needs," McCarl said.

"My whole focus," he explained, "has been to estimate what damages arise if the 'bulldozer' of climate change hits us, and what opportunities we have for agriculture to help mitigate them."

Dr. Gerald North, Distinguished Professor in Texas A&M's Department of Atmospheric Sciences, agreed with McCarl about Texas' vulnerability, saying that, outside of Alaska, Texas may be the state most vulnerable to the effects of climate change.

"Texas will face a number of challenges, and its main problem is water," North said. "Other things, such as increased population, the decline in the Ogallala Aquifer, and increased urbanization will combine with climate change to make it worse."

Since research shows that the state's average temperature has increased by 2 degrees Fahrenheit in the last three decades and will continue to rise, North, who speaks on climate change all over the state and country, said precipitation would have to increase by 50 percent to maintain current water volumes in the state's rivers and lakes.

"The high temperatures experienced during the terrible drought in the 1950s will become the average temperature," he said.

North co-edited a 1995 book, *Impact of Global Warming in Texas*, and is currently working on a revision due in 2008. McCarl is one of the chapter authors.

Climate change primer

Intergovernmental Panel on Climate Change–The World Meteorological Organization and United Nations Environmental Program established the Intergovernmental Panel on Climate Change (IPCC) in 1988. Its goal is to assess scientific, technical, and socio-economic information relevant to the understanding of climate change, its potential impacts, and options for adaptation and mitigation. It has issued four Assessment Reports (1990, 1995, 2001, and 2007) along with other reports. A summary for policymakers of the "Synthesis Report of the Fourth Assessment Report," which was released in November 2007 is available at http://www.ipcc.ch/.

The following are some findings of the synthesis report:

- Warming of the world's climate is "unequivocal": 11 of the past 12 years (1995-2006) rank among the 12 warmest years since 1850.
- It is "likely" (meaning a 66 percent likelihood) that there has been significant man-made warming on every continent except Antarctica over the past half-century.
- Continued greenhouse-gas emissions at or above current rates would induce climate changes that would be "very likely" (meaning a 90 percent likelihood) to exceed those observed during the twentieth century.
- Fossil fuels will dominate the world's energy portfolio until at least 2030, and emissions are expected to rise by 25-90 percent during that time.
- Given our current understanding, it is too difficult to estimate the extent of future sea-level rise.

(taken from Nature News at www.nature.com/news)

Global warming–Scientists say that the earth's temperature has warmed by 0.6 ˚C to 0.9 ˚C in the last 100 years. They expect it to warm by as much as 10 ˚F over the next 100 years.

Greenhouse Gases (GHG)–Greenhouse gasses, which include carbon dioxide, methane, and nitrous oxide, trap heat, thus increasing temperatures. The IPCC maintains that, since the industrial revolution began around 1750, carbon dioxide levels have increased 35 percent; and methane levels have increased by 148 percent.

Climate, Weather and Water on the Web

Compiled by Ric Jensen

Climate

- **The Texas Weather Connection**

  http://twc.tamu.edu

  Information about climate factors (temperatures, dewpoint, humidity, wind, and precipitation) from many regions throughout Texas.
- **The Climate Atlas of the United States**

  http://gis.ncdc.noaa.gov

  National maps that can display trends associated with temperature, precipitation, wind and other variables.
- **The National Drought Mitigation Center**

  http://drought.unl.edu/monitor/monitor.htm

  Current drought conditions, the number of dry and rainy days and the impact of drought on water supplies and vegetation.

Climate Change

- **EPA's Climate Change Site**

  http://www.epa.gov/climatechange/

  Comprehensive information on the issue of climate change, including science, U.S. climate policy, greenhouse emissions, health and environmental effects, and what you can do.
- **United Nations Gateway to the UN System's Work on Climate Change**

  http://www.un.org/climatechange/

  Climate change information from various UN agencies, featuring scientific reports from the UN, developments on efforts to reach a new international climate change agreement, climate change events, news, webcasts, projects in the field, and climate change information for youth.

Weather

- **The National Weather Service**

  http://www.weather.gov

  Current and historical weather information, including weather conditions, weather forecasts, and weather watches and warnings. Users can sign up for automatic weather alerts about specific locations.

Water Resources

- **The National Weather Service's Advanced Hydrologic Prediction Service**

  http://water.weather.gov

  Water-related information, including current conditions and forecasted flows for rivers, precipitation, and runoff.
- **The U.S. Geological Survey's National Water Information System**

  http://waterdata.usgs.gov/nwis

  Information such as trends associated with river flows, water levels in reservoirs and groundwater conditions, water quality parameters, water temperature, dissolved oxygen, salinity, and pH.

Surface Water Reservoirs

- **Texas Water Development Board's Texas Water Conditions**

  http://www.twdb.state.tx.us/publications/reports/waterconditions/watercon.asp

  Information, current and historical, about the volumes of water stored in major surface water reservoirs and information about trends related to the amount of water stored in Texas lakes.

Groundwater

- **Texas Water Development Board's Water Information Integration and Dissemination System Web site**

  http://wiid.twdb.state.tx.us

  Detailed information about individual water wells. This system uses a geographic information system-based tool to show locations of water wells and download data on water levels and water quality. Reports that were developed about on-site conditions before a well was drilled and installed can be downloaded.

- **U. S. Geological Survey's Groundwater Data for the Nation program**

  http://waterdata.usgs.gov/nwis/gw

  A variety of groundwater data, including information about current or real-time groundwater levels as well as daily, monthly, and annual data and statistics.

Irrigation Scheduling

Web-based information networks that present real-time data on potential evapotranspiration and other climate parameters to help urban and rural water users schedule irrigation.

- **Texas Evapotranspiration Network**

  http://texaset.tamu.edu/

- **North Plains Weather Network**

  http://amarillo2.tamu.edu/nppet/petnet1.htm

- **Texas High Plains Evapotranspiration Network**

  http://txhighplainset.tamu.edu/

- **Uvalde Research and Extension Center's Potential Evapotranspiration Network**

  http://uvalde.tamu.edu/

- **The Crop Weather Program, Texas AgriLife Research and Extension Center at Corpus Christi**

  http://cwp.tamu.edu/

Climate change conference set

The River Systems Institute is hosting "Forecast: Climate Change – Impacts on Texas Water," April 28-30, 2008, at the Texas State Capitol Extension in Austin.

The conference will take a comprehensive look at what is known about climate change and what needs to be known to prepare for the local impact on Texas water resources and on the communities, both natural and human, that depend on them.

The conference will feature national climate change scientists who have conducted cutting-edge work in the prediction of global warming and the impending changes on the Earth's climate and state scientists who are working to understand the impact on Texas and its water resources.

Speakers include Drs. Warren Washington of the National Center for Atmospheric Research; Connie Woodhouse of the University of Arizona's Department of Geography and Regional Development, Gerald North of Texas A&M University's Department of Atmospheric Sciences, Bruce McCarl of Texas A&M's Department of Agricultural Economics, and Ruby Leung of the Pacific Northwest National Laboratories.

The conference is being co-hosted by Texas Water Resources Institute, an entity of Texas A&M AgriLife, and Environmental Sciences Institute of The University of Texas at Austin. Co-sponsors include Guadalupe – Blanco River Authority, Lower Colorado River Authority, Magnolia Charitable Trust, The University of Texas's Jackson School of Geosciences, and U.S. Geological Survey.

For more information, visit http://www.rivers.txstate.edu/CCTW/CCTW08index.htm.